EFFECT OF GROW-APART SYNDROME ON THE HEAD DIAMETER, BODY LENGTH AND CANNIBALISM IN *CLARIAS GARIEPINUS* (BURCHELL, 1822) HATCHLINGS

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Abstract

Nine indoor rectangular (0.53 m^3) concrete tanks were each stocked with induced-bred *Clarias gariepinus* fry (mean ± standard error of mean (s.e.m.) =1.63±0.61g) at 500 fry per tank. *Ad libitum* feeding, restricted feeding and no-feeding treatments each of mixed zooplankton and hatched brine shrimp (*Artemia salina*) replicated three times was used. One hundred and fifty fry each weighing 2.22 ± 1.22 g (mean ± s.e.m) from the indoor rearing exercise were stocked in each of nine 150 m^3-capacity outdoor earthen ponds. These were similarly replicated and treated as in the indoor tanks but 40% crude protein crumbled artificial feed was used. The increase in body length, head diameter and the frequency of cannibalism in the fry were monitored indoor and outdoor for 14 days. The results showed that fish reared in the outdoor earthen ponds had better increases in standard lengths (SL) and total lengths (TL) than those reared in indoor tanks. There were significant differences ($P < 0.05$) in mean increases in the TL and SL per day for the jumpers (JP) whether reared indoor or outdoor. On the contrary, no significant differences ($P > 0.05$) in increases in SL and TL per day were recorded for the non-jumpers (NJP) whether reared indoor or outdoor. Fish fed *ad libitum* showed better increases in length and head diameter for both the jumpers and the non-jumpers than those on other feeding regimes. Unlike in outdoor rearing, increase in the head diameter of the JP and the NJP raised on different feed regimes was significantly different ($P < 0.05$) for indoor hatchery. The 36.75% mortality obtained in indoor hatchery was due mainly to cannibalism. Little or no feeding of *C. gariepinus* fry therefore enhanced grow-apart syndrome which encouraged cannibalism, differences in body length and head diameter.

Key words: jumpers, non-jumpers, restricted feeding, *ad libitum*, mortality, cannibalism.

1. Introduction

The production of quality fish seeds forms the bedrock of fish farming in Nigeria. One of the methods developed for commercial production of fingerlings is the artificial mass propagation technique. The acid test of the viability of this technique is the survival of the hatchlings so produced. Members of the family Clariidae are, with Cichlidae, the most used fish species in African aquaculture. Among the clariids, *Clarias gariepinus* (Burchell, 1822) and *C. angularis* (Linnaeus, 1758) are the most of ten raised fish species. In the 1980s, the reproductive cycle of another member of the African clariids, *Heterobranchus longifilis* (Valenciennes, 1840) was mastered in captivity (Legendre, 1986). This species is characterized by a high fecundity varying from 26,000 oocytes per kg of female body weight in the dry season to 68,000 oocytes per kg of female body weight in the rainy season.

Craig and Kiplings (1983) stated that cannibalism plays a regulatory role in natural fish populations but could be a major problem in high density fish culture. Among the African clariid catfishes, cannibalism at fry and fingerling stages is a major problem hampering large scale production of catfish fingerlings. For example, *C. gariepinus* has been reported to lose about 65% of its fry and fingerlings to cannibalism under culture condition (de Kimpe and Micha, 1974; Van der Waal, 1978) and in the wild (Grownewald and Van, 1964; Bruton, 1979). Aluko *et al.* (2001) reported that hatchlings produced within the first hour of onset of hatching comprising less than 3 % of hatchlings in *C. gariepinus* could possibly be responsible for the high loss of its fry and fingerlings as reported earlier by de Kimpe and Micha (1974). Observations made by the authors of the present study indicated that hatchlings produced within the first hour of onset of hatching resorbed their yolk sac first and began active swimming and foraging for food as jumpers three days before some septic non-jumpers hatched. The resultant effect of this was the differential growth of these two groups of hatchlings which consequently triggered cannibalism.

Cases of cannibalism have also been reported for other important culture species such as turbot

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(*Scophthalmus maximus*) (Smith, 1979), eels (*Anguilla anguilla*) (Degani and Levanon, 1983) and sea bass (*Dicentrarchus labrax*) (Kentouri, 1980). Hecht and Appelbaum (1988) reported that hungry catfish begin foraging for food by actively swimming at 45° to the bottom of the pond in so-called helicopter mode, leading to cannibalism. It was hence opined that inadequate feeding could be a factor in initiating cannibalism in clariid catfishes. Both Hecht and Appelbaum (1988) and Aluko *et al.* (2001) reported that cannibalism in C. *gariepinus* occurred within 7 days after hatching when foraging hungry hatchlings identified and attacked the tails of their siblings and held them firmly in their mouths (Type 1 Cannibalism). Aluko *et al.* (2001) maintained that Type 1 cannibalism ceased to be significant after the fish had reached 80 mm while Type II cannibalism is characterized by the prey being swallowed head first and whole. This development emanated from size variation in the population resulting in aggressive behaviors in bigger fish, consumption of smaller siblings, and a sudden and rapid reduction in size of the population with a visible size variation (Aluko *et al.*, 2001). This study was therefore designed to further investigate the effect of grow-apart syndrome on cannibalism, head diameter and body length of *C. gariepinus* hatchlings.

2. Materials and Methods

This study was carried out at the hatchery complex of Akia Agro-Allied Productions Limited fish farm, Igbide, Delta State, Nigeria. Igbide is located about 35 kilometers from Ughelli, off the Warri-Port Harcourt highway.

(*a*) Experimental Procedure

Four male and eight female *C. gariepinus* breeders (mean weight ± standard error of mean (s.e.m.) = 550±1.2 *g*) were selected from an earthen brood stock pond (500 m^2) and placed in two plastic containers (25 L) with 10 L of clean dechlorinated tap water in each. The female breeders were selected based on ovarian biopsy of the oocytes as described by Legendre (1986). The female breeders were injected at 20 h with 5mg kg^{-1} body size of fish carp pituitary extract and left for 11h latency period at a temperature of 25±1° C. Eggs were stripped and fertilized at 7 h the next day in accordance with the method described by Hogendoorn and Vismans (1980). Two circular concrete tanks (3.54 cm^3) were used to incubate (27 h) and hatch the eggs at 25±1° C from strands of polyethylene fibres (*kakabans*) submerged in water. The hatchlings produced within the first hour of onset of hatching were collected to be used as jumpers. Those produced thereafter were collected to be used as non-jumpers. The sac fry were monitored for 5 days until the yolk sacs were resorbed. The swim-up fry were fed with mixed zooplankton and also monitored for 6 days until evidence of type I cannibalism (Aluko *et al.*, 2001) was noticed. The fry were subsequently transferred to 9 indoor concrete tanks.

(b) Indoor Fry Management

Four thousand five hundred hatchlings (mean total length ± s.e.m.=1.63 ± 0.61 cm) were stocked in nine indoor rectangular concrete tanks (0.70×1.50×0.50 m^3) with 0.62 m depth of water at 500 hatchlings per tank. Three experimental feed treatments (*ad libitum* feeding, restricted feeding and no-feeding) were replicated three times and used. The increase in body length and increase in head diameter of the fry were measured, and the frequency of cannibalism monitored for 14 days. To measure the head diameter, a metal pair of dividers was used. As the fry was swimming in water, the pointed tips of the pair of dividers were opened to the diameter of the head of a particular fry being measured. The open tips of the pair of dividers used were transferred each time to a centimetre ruler to read out the distance apart which is the measurement of the head diameter and to record the head diameter (cm) of each fry measured. Daily survival of fry in each tank was recorded by direct counting and the fry were monitored for any cannibalism. Hatchlings on *ad libitum* feed treatment were fed four times daily (8.00 am, 12.00 noon, 4.00 pm and 8.00 pm), those on restricted feed treatment were fed once every other day, and those on non-feed treatment were not fed throughout the 14 days study period. Mixed zooplankton obtained from the fish farm and brine shrimp (*Artemia salina)* hatched in the hatchery's laboratory served as feed sources during the indoor fry rearing period.

(c) Outdoor Fry Management

One thousand three hundred and fifty fry (mean total length ± s.e.m. = 2.22±1.22 cm) were randomly stocked in nine outdoor earthen nursery ponds (25×10×0.6 m^3) with 0.62 m depth of water at 150 fry/pond in accordance with the 3 replicate feed treatments described above. The fry on *ad libitum* and restricted feed treatments were fed with powdered 40 % crude protein artificial fish feed for 14 days. Fry on non-feed treatment were allowed to depend on the autochthonous food production in the ponds. Weekly measurements of length and fish survival were carried out.

(d) Analysis of Experimental Results

The data for the increase in length (cm), increase in head diameter (cm), and cannibalism (%) were statistically analysed for significant differences ($P<0.05$) by the analysis of variance (ANOVA) (Steel and Torrie, 1995). Any significant differences were partitioned by the Duncan's Multiple Range Test using the computer package, Statistical Package for Social Sciences (SPSS).

Table 1*a*:. Mean Length increase of jumper and non-jumper *C. gariepinus* hatchlings, fed in indoor concrete hatchery tanks for 14 days.

Fish type	Feeding regime	Mean Standard Length (cm)				Mean Total Length (cm)			
		Initial	Final	Mean increase ± S.E	Significant level	Initial	Final	Mean increase ± S. E.	Significant level
Jumper (JP)	*Ad libitum*	2.17	3.31	$1.14 \pm 1.48 \times 10^{-16}$		2.60	3.97	1.37± 0.02	
	Restricted feeding	1.64	2.50	$0.86 \pm 1.73 \times 10^{-02}$		1.97	3.00	1.03 ± 0.07	
	Non-feeding	1.73	2.18	$0.45 \pm 1.28 \times 10^{-16}$		0.79	1.21	0.55 ± 0.67	
Non-jumper (NJP)	*Ad libitum*	1.06	1.21	$0.15 \pm 1.73 \times 10^{-02}$		1.28	1.45	0.17 ± 0.00	
	Restricted feeding	0.97	0.91	$-0.06 \pm 3.33 \times 10^{-02}$	*	1.09	1.09	0.00± 0.33	n.s.
	Non-feeding	0.66	1.01	$0.35 \pm 5.77 \times 10^{-03}$		0.79	1.21	0.42 ± 0.00	

* = Significant at 95% probability ($P < 0.05$); n.s. = not significant at 95% probability; S.E. = Standard error of mean.

Table 1b: Mean increase in length per day of jumper and non-jumper *Clarias gariepinus* hatchlings fed in indoor concrete hatchery tanks for 14 days.

Fish type	Feeding regime	Standard length (cm)		Total length (cm)	
		Mean increase/day	Significant level	Mean increase/day	Significant level
Jumper (JP)	*Ad libitum*	0.080		0.100	
	Restricted feeding	0.060	*	0.070	*
	Non-feeding	0.032		0.039	
Non-jumper (NJP)	*Ad libitum*	0.010		0.012	
	Restricted feeding	-0.004	n.s.	0.000	n.s.
	Non-feeding	0.025		0.030	

* = Significant at 95% probability, n.s. = not significant at 95% probability.

Table 2a: Mean length increase of jumper and non-jumper *C. gariepinus* hatchlings fed in outdoor earthen ponds for 14 days[1]

Fish type	Feeding regime	Mean standard length (cm)[2]			Mean total length (cm)[2]		
		Initial	Final	Mean increase ± Standard error of mean	Initial	Final	Mean increase ± standard error of mean
Jumper	*Ad libitum*	3.31	8.23	4.97 ± 3.33E-03[a]	3.97	9.93	$5.96 \pm 2.96 \times 10^{-16}$[a]
	restricted feeding	2.50	6.25	$3.75 \pm 2.31 \times 10^{-2}$[b]	3.00	7.50	3.75 ± 0.10[b]
	Non-feeding	2.18	5.45	$3.27 \pm 1.28 \times 10^{-16}$[c]	2.62	6.55	$3.93 \pm 1.96 \times 10^{-16}$[b]
Non-jumper	*Ad libitum*	1.21	2.54	1.33 ± 0.00[a]	1.45	3.05	1.60 ± 0.00[a]
	restricted feeding	0.91	1.91	1.91 ± 0.00[a]	1.09	2.29	1.20 ± 0.33[a]
	Non-feeding	1.01	2.12	2.12 ± 0.00[a]	1.21	2.54	1.33 ± 0.00[a]

[1]Means of the same fish type in different feeding regimes in a column followed by the same letters are not significantly different ($P > 0.05$).
[2]Mean initial and mean final values of standard and total lengths

Table 2b: Mean length increase per day of jumper and non-jumper *Clarias gariepinus* hatchlings fed in outdoor earthen ponds for 14 days.

Fish type	Feeding regime	Mean increase in length/day (cm)			
		Standard length	Significant level	Total length	Significant. level
Jumper (JP)	*Ad libitum*	0.36		0.43	
	Restricted feeding	0.26	*	0.26	*
	Non-feeding	0.23		0.29	
Non-jumper (NJP)	*Ad libitum*	0.10		0.11	
	Restricted feeding	0.07	n.s.	0.09	n.s.
	Non-feeding	0.08		0.10	

* = Significant at 95% probability; n.s. = not significant at 95% probability.

Table 3: Type of fish and type of fish length of *Clarias gariepinus* in response to different feeding regimes in both indoor and outdoor hatchery facilities[1].

Feeding regime	Indoor: Mean increase in length ± S.E.M. (cm)			Outdoor: Mean increase in length ± S.E.M. (cm)		
	Jumper	Non-jumper	Significant Level	Standard length	Total length	Significant Level
Ad libitum	5.47 ± 0.22	1.47 ± 0.06		3.15 ± 0.81	3.78 ± 0.98	
Restricted feeding	4.13 ± 0.17	0.94 ± 0.15	*	2.38 ± 0.62	2.69 ± 0.83	n.s.
Non-feeding	3.60 ± 0.15	1.22 ± 0.05		2.02 ± 0.48	2.63 ± 0.58	

[1]* = Significant at 95% ($P < 0.050$; n.s. = not significant; ± S. E.M. = Standard error of mean.

Table 4a: Mean increase in head diameter and mean increase in head diameter per day of *Clarias gariepinus* hatchlings fed in indoor concrete hatchery within 14 days.

Fish type	Feeding type	Mean head diameter (cm)[1]					
		Initial	Final	Increase± S.E.M	Significant level	Increase/day ± S.E.M.	Significant level
Jumper	*ad libitum*	1.85	4.63	$2.783 \pm .23 \times 10^{-16}$		$0.20 \pm 1.22 \times 10^{-17}$	
	restricted feeding	1.55	3.88	2.33±0.00	*	0.17±0.00	*
	non-feeding	0.64	1.60	0.96±0.00		0.07±0.00	
Non-jumper	*ad libitum*	1.03	2.16	$1.13 \pm 6.41 \times 10^{-17}$		$0.08 \pm 4.01 \times 10^{-18}$	
	restricted feeding	0.80	1.68	0.88±0.00	*	0.06±0.00	*
	non-feeding	0.20	0.42	$0.22 \pm 8.01 \times 10^{-18}$		$0.02 \pm 1.53 \times 10^{-18}$	

[1]Initial and final values of head diameter for jumper and non-jumper, S. E. ± standard error of mean, * = significant at 95% probability ($P < 0.05$).

Table 4b: Head diameter increase of *Clarias gariepinus* hatchlings in response to different feeding regimes in indoor hatchery tanks within 14 days[1].

	Feeding regime	Mean increase ± Standard error of mean (cm)
Mean increase in head diameter (cm) of jumpers	*ad libitum*	1.96 ± 0.37^a
	restricted feeding	1.61 ± 0.32^a
	non-feeding	0.59 ± 0.17^b
Mean increase in head diameter per day (cm) of non-jumpers	*ad libitum*	0.14 ± 0.026^a
	restricted feeding	0.11 ± 0.023^a
	non-feeding	0.04 ± 0.012^b

[1]Means followed by the same superscripts are not significantly different ($P < 0.015$).

3. Results

The results of the mean increase in lengths of the jumper and non-jumper of *C. gariepinus* hatchlings, fed natural diets in indoor hatchery tanks, are shown in Tables 1a and 1b. The response of the jumpers to the feeding regimes (i.e. *ad libitum*, restricted and non-feeding) indicated that growth increase in both the standard length (SL) (3.31 cm) and total length (TL) (3.97 cm) of fish were better in those fed *ad libitum* than when fed restrictedly or non at all (Table 1a). The increase in SL and TL of the non-jumpers followed a similar trend except for the shortfalls in increase recorded for the SL (0.06 cm) and TL (0.00 cm) when the fish were fed restrictedly. Data analysis of the mean increase in lengths within the 14 days study period showed that the SL of fish was significantly different among the feeding regimes (P<0.05). No such difference was recorded for the TL (P>0.05). The mean increase in length per day (Table 1b) for the SL and the TL of the jumpers was however significantly different among the feeding regimes (P<0.05). The SL and the TL of the non-jumpers did not show any significant daily increase in length among the feeding regimes (P>0.05).

Comparatively, the growth responses of the fish hatchlings were better in terms of the standard (SL) and the total (TL) lengths, when stocked in outdoor earthen ponds (Tables 2a and 2b) than when stocked in indoor hatchery tanks. The mean length increases of fish subjected to *ad libitum* feeding regimes for both the jumpers (SL=4.97 cm, TL=5.96 cm) and non-jumpers (SL=1.33 cm, TL=1.60 cm) were better than those recorded for the other feeding regimes (i.e. restricted and non-feeding) (Table 2a). The non-jumpers on non-feeding regime showed better increases in SL (1.11 cm and TL 1.33 cm) than those fed restrictedly (SL=0.91 cm, TL=1.20 cm). As recorded for fish stocked in the indoor hatchery tanks, there were significant differences in the increase in the SL and the TL of fish among the feeding regimes (P<0.05) but not for the non-jumpers (P>0.05) (Table 2a). The mean increases in SL and TL per day for the jumpers (Table 2b) were also significantly different among the feeding regimes (P<0.05); whereas the non-jumpers did not show such differential increase.

Table 3 shows the results of the analysis of the performance of the jumpers and non-jumpers with the different feeding regimes; and the responses of the fish standard and total lengths to the various feeding regimes. The effect of non-feeding and restricted feeding on the fish standard and total lengths was significantly different (P<0.05) from that resulting from *ad libitum* feeding. There was also no significant increase in SL and TL per day (P>0.05). It was noted that the type of feeding was a factor in producing increase in length per day.

The mean increases in head diameter of the catfish hatchlings cultured in indoor hatchery tanks, under different feeding regimes, are shown in Tables 4a and 4b. The mean head diameter increases of the jumpers (2.78 cm) and non-jumpers (1.13 cm) fed

Table 5a: Mean head diameter increase per day of *C. gariepinus* hatchlings in response to different feeding regimes in outdoor earthen ponds within 14 days.

Fish type	Feeding regime	Mean head increase per day (cm) ± S. E.	Significant level (P = 0.015)
jumper	*ad libitum*	0.50 ± 0.00	**
	restricted feeding	$0.42 \pm 3.70 \times 10^{-17}$	
	non-feeding	$0.17 \pm 2.12 \times 10^{-17}$	
non-jumper	*ad libitum*	$0.17 \pm 9.25 \times 10^{-18}$	**
	restricted feeding	0.13 ± 0.00	
	non-feeding	$3.29 \times 10^{-02} \pm 0.00$	

** = Significant at 99% probability (P < 0.01). S. E. = Standard error of mean.

Table 5b: Mean head diameter increase per day of *C. gariepinus* hatchlings according to fish type (i.e. jumper and non-jumper) fed in outdoor earthen ponds for 14 days.

Fish type	Mean head increase per day ± S. E. (cm)	Significant level (P = 0.01)
jumper	0.36 ± 0.05	**
non-jumper	0.11 ± 0.02	

** = Significant at 99% probability (P < 0.01); S. E. = Standard error of mean.

ad libitum was better than those fed restrictedly or none at all (Table 4a). The same trend of better head diameter increase per day was exhibited by fish fed *ad libitum* than those fed otherwise (i.e. restricted and non-feeding). There were significant differences in the increase in head diameter for both the jumpers and non-jumpers (P<0.05) based on the type of feeding (Table 4a). Considering the feeding type (i.e. feeding and non-feeding of fish indoor) alone as the determining factor for increase, there was also a significant difference in the mean increase in head diameter of fish within the 14 days study period (P<0.015) (Table 4b). However, there was no significant difference in the head diameter (P>0.015) between fish fed *ad libitum* and those fed restrictedly.

The mean increases in head diameter per day of *C. gariepinus* hatchlings in response to different feeding regimes in out-door earthen ponds are shown in Table 5a. Both the jumpers (0.50 cm) and non-jumpers (0.17 cm) showed better increases in head diameter when fed *ad libitum* than when subjected to any of the other feeding regimes. However the unfed hatchlings of both fish types recorded least values of head diameter increases. A highly significant difference (P<0.001) was recorded for the mean increase in head diameter among the feeding regimes adopted (Table 5a). A highly significant difference was also recorded for head diameter increase per day (P<0.001) of fish in the outdoor earthen ponds when the fish types were considered (Table 5b).

Tables 6a and 6b show the numbers and mean frequencies of fish types, as well as the percent cannibalism of the experimental hatchlings in indoor (Figure 1) and outdoor (Figure 2) hatchery facilities. The jumpers in the indoor tanks recorded no reduction in their numbers for any of the feeding regimes when counted on a daily basis. Jumpers subjected to the non-feeding regime (Figure 1) were highest (13 in number) and constituted 2.50 % of the population of fish in the tanks. This was followed by those on *ad libitum* feeding (11 in number) (2.20 %) and then restricted feeding (10 in number) (2.00 %). The non-jumpers, on the other hand, were most affected by reduction in number and consequently by cannibalism.

The most cannibalized non-jumpers during the 14 days study period (in-door) were those subjected to non-feeding regime (61.60 %). This gave mean values of 308 losses and 179 survivors, amounting to mean frequencies of 63.24 % and 36.76 % respectively of the total population of non-jumpers (487). When the 487 non-jumpers were added to the 13 jumpers present, it summed up to 500 hatchlings originally stocked in the tank. The percent cannibalism (61.60 %) was estimated from the number of losses (308) as a percentage of the entire population of hatchlings (500) originally stocked. This procedure was used in the estimation of the mean frequencies and percent cannibalism of hatchlings subjected to other feeding regimes (i.e. *ad libitum* and restricted feeding). Generally, jumpers (13) of the non-feeding regime were implicated in the loss/ cannibalism (Plates 1 and 2) of 308 non-jumpers (Figure 1). This result exceeded those under restricted feeding where 10 jumpers effected the loss/ cannibalism of 285 non-jumpers or under *ad libitum* feeding where 11 jumpers possibly cannibalized 271 non-jumpers. Cannibalism in this study was adjudged the cause of the outrageous reduction of fish population observed since no carcasses of dead fish hatchlings were retrieved from the hatchery tanks during daily counting, while the distended abdomens of many jumpers (Plate 1) or cannibalism proper (Plate 2) were quite obvious.

The cannibalism exhibited by the catfish hatchlings stocked in the outdoor earthen ponds (Figure 2) was lower than that recorded for fish stocked in indoor hatchery tanks. The least percent cannibalism was shown when the fish were not fed (23.67 %) than when fed *ad libitum* (28.89 %) or fed restrictedly (29.00 %). This state of affairs was corroborated by the losses and survivors of hatchlings subjected to the various types of feeding regimes (Figure 2). At the end of 14 days feeding experiment outdoor, from a total of 150 hatchlings stocked per pond, the number of surviving fish (i.e. jumpers and non-jumpers) was highest for the unfed hatchlings (i.e. 79JP+34NJP=113 survivors) followed by those fed *ad libitum* (i.e. 72JP+40NJP=112 survivors) and those fed restrictedly (i.e. 61JP+45NJP=105 survivors).

4. Discussion

The feeding regimes applied in this study were to investigate reasons for the low population densities of the African catfish (*C. gariepinus*) hatchlings (fry/ fingerlings) under culture conditions. The low level of production by most practising fish farmers in Nigeria has constituted a disincentive to the campaign for the massive production of this delicious and choice fish species. Recently (2004) a National Committee on Massive Catfish Production was constituted by concerned aquaculturists in Nigeria as a means of finding lasting solutions to the existing retrogressive system of catfish production.

In this study, the better growth response shown by *C. gariepinus* hatchlings (for increases in standard lengths (SL) and total lengths (TL) when fed *ad libitum*) indoor (Tables 1a and 2a) or outdoor (Tables 1b and 2b) than fish fed restrictedly or none at all, indicated that rapid growth of fish hatchlings is predicated upon unrestricted feeding. Catfish hatchlings at their early ages are voracious feeders and the factors implicated to influence feed intake by Lagler *et al.* (1977) include hunger, curiosity and gluttony. The retardation of growth owing to inadequate feeding was exemplified by the significant differences (P<0.05) in the SL and the TL of fish when the various feeding regimes were applied. Between the other two feeding regimes (i.e. restricted and non-feeding), the non-jumpers on non-feeding regime showed higher increases in SL and TL than those fed restrictedly (Tables 3a and 3b). It was possible that the non-jumpers under restricted feeding were under threats by the jumpers, especially in the presence of inadequate food. This situation appeared to be less in those not fed. There was the possibility of prodigious secretion of adrenalin into the blood stream due to fear of and threats from the jumpers, resulting in hyperactivity in the non-jumpers. The result of this was retarded growth in SL and TL. More research is needed in this area to establish the level of adrenalin in the blood stream of the non-jumpers in the presence of jumpers of *C. gariepinus* hatchlings.

The increase in the head diameter (HD) of the hatchlings (Tables 4a and 4b) followed the same trend as increases in the SL and the TL of the fish. It was obvious from the results that *ad libitum* feeding was necessary for the rapid expansion of head diameters of both jumpers and non-jumpers. It was also obvious that the various feeding regimes gave highly significant differences (P=0.015) in the head diameter increase of the hatchlings under outdoor pond culture.

There were no reductions in the number of jumpers both in the indoor (Figure 1) and in the outdoor (Figure 2) hatchery facilities. The survival of the jumpers under the various feeding regimes indicated their ability to withstand adverse hatchery conditions. The reduction in the number of the hatchlings was prevalent among the non-jumpers cultured in indoor and outdoor hatchery facilities. As stated in the Results section above, cannibalism was adjudged the cause of the outrageous reduction in number of the fish population both in the indoor tanks and in the outdoor earthen ponds. From the non-retrieval of the dead carcasses of fish, the observation of Type 1 cannibalism (Aluko *et al.*, 2001) and evidences of Type II cannibalism (Aluko *et al.*, 2001) (Plates 1 and 2), this conclusion was made. Therefore, measures to ameliorate the occurrence of cannibalism among *C. gariepinus* hatchlings under culture should be further investigated in order to ensure the massive production of these hatchlings.

From this study, Type I cannibalism of *C. gariepinus* occurred indoor when the fish standard lengths were 1.21±0.02 mm (under *ad libitum*), 9.10±0.03 mm (under restricted feeding) and 10.10 ± 0.06 mm (under non-feeding) (Figure 2). The values were consistent with the report of Aluko *et al.* (2001), which stated that Type 1 cannibalism in *C. gariepinus* hatchlings was recorded when the fish was below 80mm in length. Whereas Aluko and Ojo (2001) reported a loss rate of 63.25 % and survival

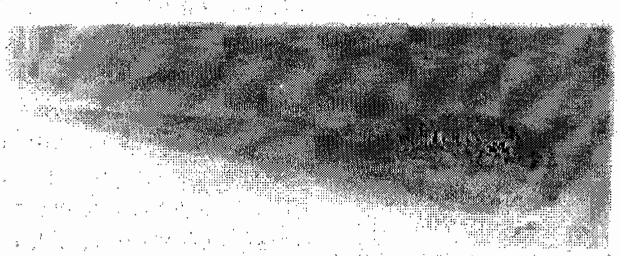

Plate 1: Distended abdomen of cannibalistic jumper

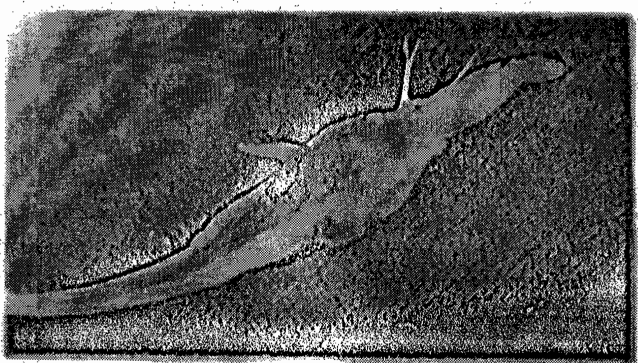

Plate 2: Cannibalism by hatching by jumper

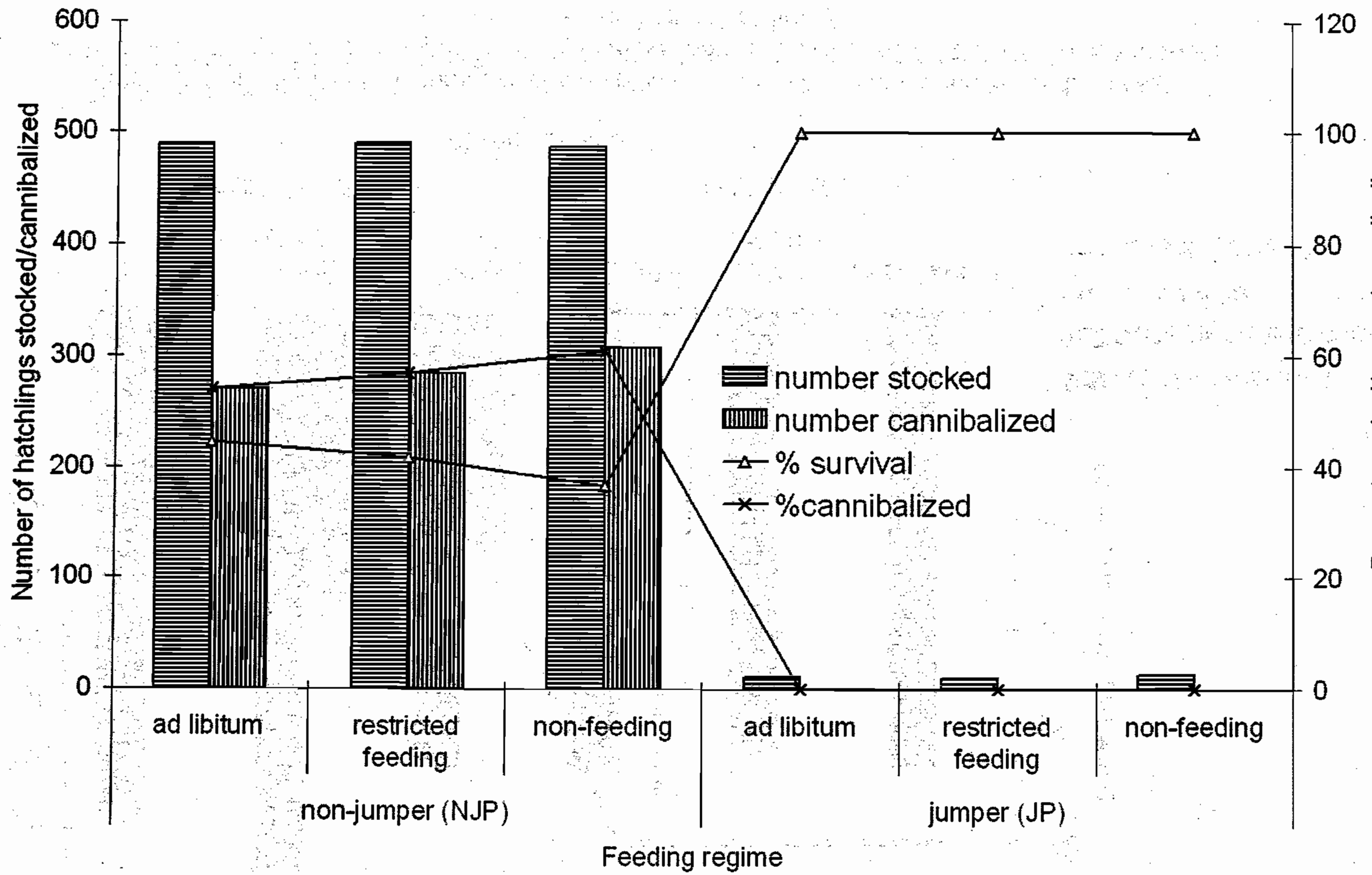

Figure 1 : Number of hatchlings (jumper and non-jumper) of *Clarias gariepinus* stocked and cannibalized, percent survival and percent cannibalized out of a total of 500 hatchlings per tank fed for 14 days in indoor hatchery tanks.

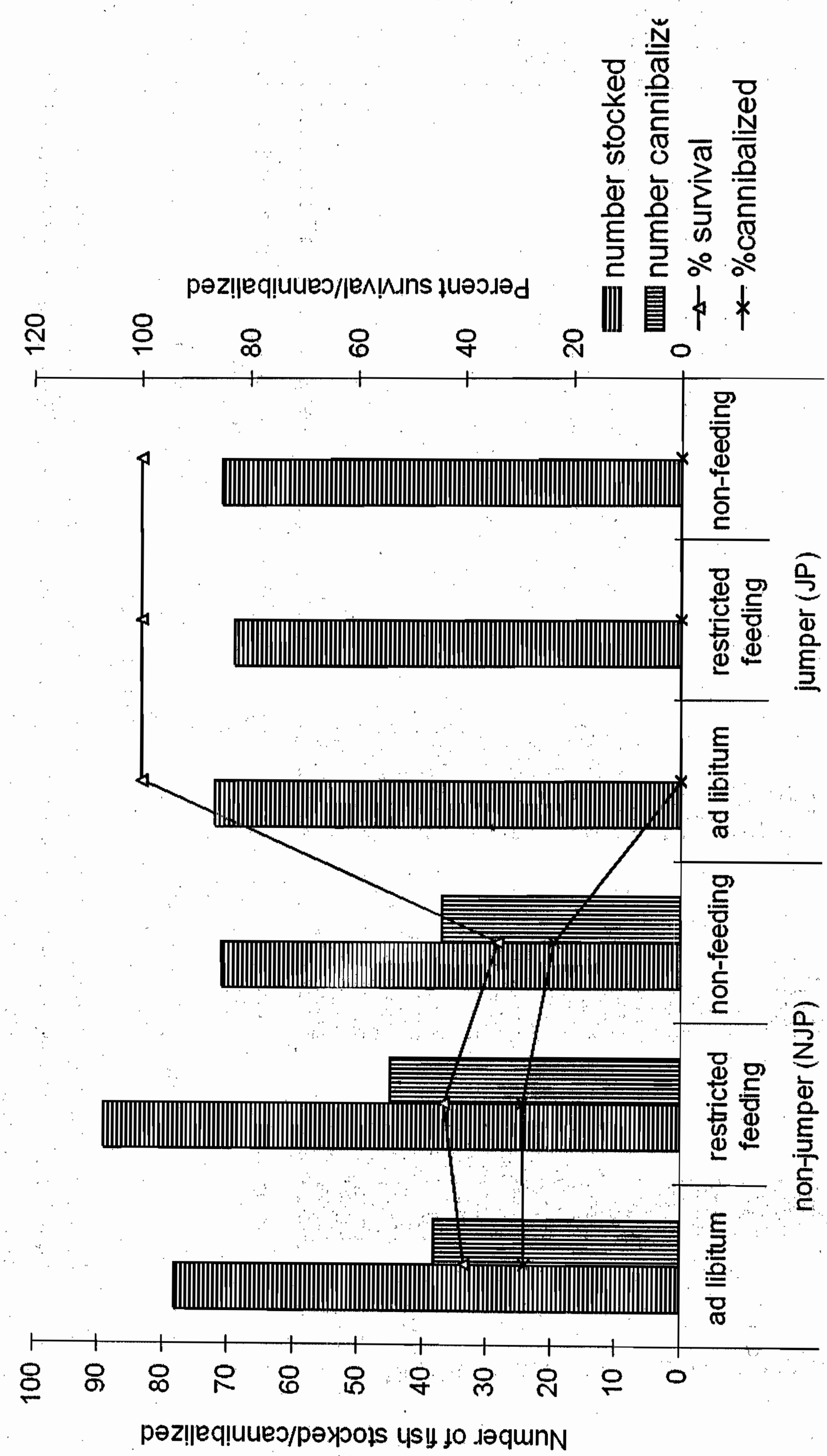

Figure 2: Number fish types (jumper and non-jumper) stocked, number cannibalized, percent cannibalism and percent survival of Clarias gariepinus hatchlings stocked at 150 hatchlings per pond in outdoor earthen ponds for 14 days.

Table 6*a*: Numbers and mean frequencies of fish types, percent cannibalism of the experimental hatchlings in indoor

	ad libitum	489	271	44.59	54.20%
	restricted feeding	490	285	41.84%	57.00%
non-jumper (NJP)	no feeding	487	308	36.76%	61.60%
		number stocked	number cannibalized	% survivors	%cannibalized
jumper (JP)	*ad libitum*	11	0	100	0.00%
	restricted feeding	10	0	100	0.00%
	no feeding	13	0	100	0.00%
non-jumper (NJP)	*ad libitum*	489	271	44.59	54.20%
	restricted feeding	490	285	41.84	57.00%
	no feeding	487	308	36.76	61.00%
		number stocked	number cannibalized	% survival	%cannibalized
non-jumper (NJP)	*ad libitum*	489	271	44.59	54.2
	restricted feeding	490	285	41.84	57
	no feeding	487	308	36.76	61
jumper (JP)	*ad libitum*	11	0	100	0
	restricted feeding	10	0	100	0
	no feeding	13	0	100	0

Table 6b: Numbers and mean frequencies of fish types, percent cannibalism of the experimental hatchlings in outdoor

		number stocked	number cannibalized	% survival	% cannibalized
non-jumper (NJP)	*ad libitum*	78	38	40	28.89
	restricted feeding	89	45	44	29.33
	no feeding	71	37	34	23.6
jumper (JP)	*ad libitum*	72	0	100	0
	restricted feeding	69	0	100	0
	no feeding	71	0	100	0

rate 36.75 % of the hatchlings when fed *ad libitum* in indoor hatchery tanks, this study recorded a loss rate of 44.59 % and survival rate of 55.41 % of the same species when fed *ad libitum* indoor (Figure 1). Differences in values could be due to experimental conditions or the sizes of fish hatchlings used. Nevertheless, the survival (63.24 %) and loss (36.76 %) rates of the present experimental fish when subjected to a non-feeding regime were consistent with the 63.25 % loss and 36.75 % survival reported by Aluko and Ojo (2001) under *ad libitum* feeding. Whereas Aluko and Ojo (2001) reported a loss rate of 54.25 % and a survival rate of 45.75 % of the catfish hatchlings stocked out door and fed *ad libitum*, this study recorded a loss rate of 53.25 % and a survival rate of 46.75 % of the same hatchlings when stocked outdoor(Table 5b). This result was consistent with the findings of Aluko and Ojo (2001). Generally, the percent cannibalism of *C. gariepinus* hatchlings in this study was higher indoor under non-feeding regime (61.60%) than outdoor under the restricted feeding regime (29.33%) (Figure 2).

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